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Wall Morphology in Historic Buildings in Pondicherry

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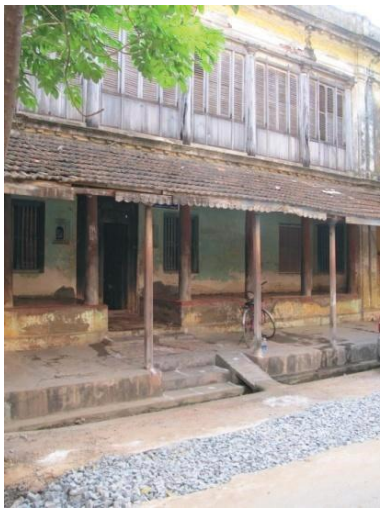
ABSTRACT

The city of Pondicherry located on the Eastern coast of India, is adorned with rich cultural heritage from the pre-historic to modern colonial era. The monuments built during the French colonial rule still exist and are in use. A considerable effort in the field of cultural heritage preservation has been undertaken by the Government of Pondicherry, ably supported by organizations such as INTACH. Programmes such as Asia -Urbs helped in preserving the architectural heritage of Pondicherry. The collapse of La Mairie de Pondicherry on 29 November 2014 brought forth issues related to previous conservation efforts. An overall understanding of the structural typology, material deterioration and distress is essential in understanding the reasons for the collapse of La Mairie de Pondicherry, and is crucial to ensure the structural health of similar structural typologies in Pondicherry and for developing an appropriate structural conservation protocol for these buildings.



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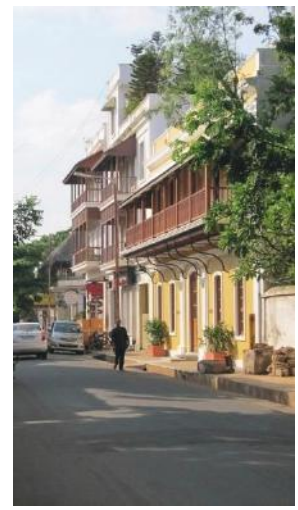

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Figure 1: (a) Architectural Character of Tamil Town; (b) Layout of Boulevard Town of Pondicherry; (c) Architectural Character of French Town. (Image Credits – INTACH Pondicherry)

Urban Heritage of Pondicherry

Pondicherry[1] is the French interpretation of the original name 'Puducheri'. The present urban form of Pondicherry came into being during the extensive French colonial rule. In the old historical accounts, the town is mentioned as either 'Poduke' or 'Vedapuri'. This settlement had good trading relations with Rome and Greece as evident in the archaeological excavations at Arikamedu which is about 4km south of Pondicherry (Arunraj T, 2009). Under the Chola rule, this town came to be known as 'Puducheri' which means new town in Tamil (INTACH, Pondicherry, 2010). The French established it as their trading port and subsequently fortified the entire settlement. The orthogonal layouts of streets were assumed to be in similar lines as the French Bastide Towns.[2] However recent research points to its roots in the master plan made by the Dutch for the development of Pondicherry in 1694 (Deloche, 2005). After the siege in 1761, the British destroyed this town. It was however returned to the French in 1765 after which, there was active reconstruction especially on the old foundations. (Deloche, 2005).

The town is divided into French and Tamil settlements by a Grand Canal which was completed in 1788 as a storm water drain, marking an informal boundary between the two (Deloche, 2005). The French settlement has a distinct European style akin to the Parisian villas while the Tamil or indigenous settlement had more of a vernacular character. These two styles define the cross-cultural heritage that manifests in Pondicherry (**Figure 1**).

The French town and Tamil town in Pondicherry have distinct architectural characteristics. The techniques of construction incorporated were similar in both towns.The French town, which developed along the coastal zone of Pondicherry, has two major typologies namely the public buildings and residential buildings while the Tamil town

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Figure 2: *(a) La Mairie de Pondicherry before collapse; (b) Condition of verandah before collapse (Image Credits – NCSHS, IIT Madras)*

was mostly residential. Bricks and timber were the most preferred building material; whereas stone had limited usage (INTACH, Pondicherry, 2010).

The structures in French town have load-bearing walls with lime or mud mortar as binding agents. The ceiling system comprises of steel or timber beams and joists with Madras Terrace Roofing. Madras Terrace Roofing is a system in which brick on edge with lime mortar is laid on closely spaced timber joists (BIS 2119:1980, 1980). This system is popular and most commonly used roofing system here. Arches and pillars are constructed in brickwork. The use of timber in French town houses is limited to the roofing system. A similar structural system was incorporated in Tamil town but the variation is in the composition of spaces.

Heritage Conservation Efforts

The built heritage of Pondicherry is categorized under un-protected monuments.[3] Government of Pondicherry along with support from non-governmental organizations (NGOs) such as Indian National Trust for Art Culture and Heritage (INTACH) has taken up the mantle for preservation of cultural heritage in Pondicherry. Preservation efforts such as Asia-Urbs Programme[4] has been able to etch the idea of built and cultural heritage preservation among the stakeholders. Some notable outcomes of these efforts were the restoration of Hotel de L`Orient and Vysial Street restoration – awarded the coveted UNESCO Asia Pacific Awards for Cultural Heritage Conservation- Outstanding Project in year 2000 and Award for Merit in year 2008, respectively.[5]

The collapse of La Mairie de Pondicherry on 29 November 2014, a listed heritage structure undergoing restoration (TNN, 2014), brought forth issues related to previous conservation efforts. An overall understanding of the structural typology, material deterioration and distress is essential in understanding the reasons for the collapse of La Mairie de Pondicherry, and is crucial to ensure the structural health of similar structural typologies in Pondicherry and for developing an appropriate structural conservation protocol for these buildings.

This paper attempts firstly, to examine and analyse possible causes of distress

Figure 3: La Mairie de Pondicherry after collapse (Image Credits – NCSHS, IIT Madras)

and collapse of La Mairie de Pondicherry specifically with reference to wall morphology and secondly, to put forward a case for a proper condition assessment of similar heritage structures in Pondicherry.

1. The Collapse of La Mairie de Pondicherry

Hotel de Ville or La Mairie de Pondicherry (as it was called) dated back to 1870-71. This building was listed as Grade 1 heritage structure (INTACH, Pondicherry, 2012). This building was located on the Goubert Avenue in the French Town and it was used earlier as Town Hall and subsequently it housed the Municipality of Pondicherry. The building possessed architectural characters akin to French colonial buildings in the precinct.

This 147 years old structure showed distress due to improper maintenance. Most of the structural elements were distressed. The distress was caused due to moisture and plaster had decayed severely. Cracks were observed on the masonry as well as on the Madras Terrace Floor (**Figure 2**). The structure of historical and architectural landmark value was taken up for repair and restoration but collapsed while the work was in progress (**Figure 3**) (TNN, 2014).

The structure of the La Mairie de Pondicherry was composed of load-bearing masonry walls. The floor and roof were made of Madras Terrace construction supported by timber and steel joists. Steel joists were predominantly used in larger central rooms while timber joists were used in other rooms.

For the masonry work, brickwork in mud mortar was interlaced with vertical and horizontal bands of brickwork in lime mortar. The bands of brickwork in mud mortar were typically 70-80 cm in height, whereas those in lime mortar were 30 cm in height. The brickwork of the arches or at positions near floors and at the boundary of openings was typically in lime mortar as bonding material. The bands of masonry in lime mortar were possibly meant to provide confinement to the weaker portion of the wall, i.e. brickwork in mud mortar. The masonry walls were originally plastered from the exterior and interior in lime. The structure did not have a damp-proofing course, which meant moisture from the ground would rise up through the masonry walls by capillary action.

Figure 4: Load bearing masonry wall portions from the debris showing thick cement plaster. (Image Credits – NCSHS, IIT Madras)

In past two decades when the structure was in service, renovation works were undertaken by the Public Works Department (PWD) -Government of Puduchery in which the brickwork was plastered from the exterior and interior with a thick layer of cement plaster. **Figure 4** illustrates the presence of a thick cement plaster. For a structural masonry wall in brickwork with mud mortar and lime mortar, with no damp-proofing course and subjected to rising dampness by capillary action, the impervious layer of cement plastering is a serious hazard as it does not permit the rising dampness to evaporate through the wall plaster. Original plastering in lime or mud would have permitted exit of moisture from the walls, owing to the porosity of the plaster, thereby keeping the masonry wall in good structural health (**Figure 5**). Moreover, regular refurbishment of the plaster and repointing of bed-joint mortar are essential in such walls as the cyclic process of escape of moisture leads to deterioration of plaster and bedding mortar, the sacrificial layer (NCSHS, 2015).

The Reasons for the Collapse of La Mairie

The collapse of the La Mairie de Pondicherry has been understood to have occurred after the removal of the cement plaster on the interior face of one of the primary load-bearing walls

> **The thick cement plaster was on one hand trapping the moisture within the walls and on the other hand, was playing a structural role by confining the weakened walls and sustaining the load-carrying capacity of the wall.**

in the north-south axis. The removal of the cement plaster approximately 4 cm thick lead to compression failure in the load-bearing walls. This is confirmed by the formation of vertical cracks and bulging of plaster, which is a very rare phenomenon. Cement plastering being impervious, would trap the moisture, and retain it within the masonry walls which were laid in mud mortar and lime mortar. Wet mud has poor or no compressive strength; wet compressive strength of bricks is also lower than the dry compressive strength.

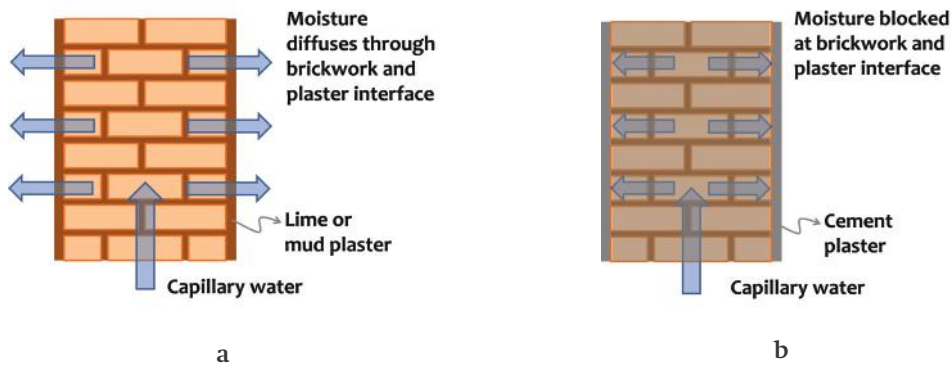

Figure 5: *(a) Illustration showing behavior of moisture in brick masonry with mud/lime plaster; (b): Illustration showing moisture blocked in brickwork and plaster interface due to cement plaster*

The thick cement plaster was on one hand trapping the moisture within the walls and on the other hand, was playing a structural role by confining the weakened walls and sustaining the load-carrying capacity of the wall. The use of cement plastering in such a building can be described as the single-most deleterious intervention that gradually led to the structural failure of the building (NCSHS, 2015). Thick rich cement plaster has clearly been observed in the load-bearing walls of the Mairie building (**refer Figure 4**). Possibly, the confinement provided by the cement plaster layer to a highly deteriorated brick wall in mud mortar was so critical as to lead to collapse on de-plastering.

There is some documentary evidence[6] of structural failure of mud walls during removal of rich cement plaster from these walls. It is understood from the adobe structures in the New Mexico region, that cement plastering adopted in these mud constructions (in place of original mud plastering) had detrimental effects on the structural health of these walls (D`Ayala & Benzoni, 2012).

Examination of the base and plinth of the wall that collapsed first shows no discernible signs of crushing at the base, implying that the crushing failure of the brick masonry at approximately one meter above the finished ground level caused the collapse of the wall. This subsequently triggered the collapse of the floor and adjoining walls. The foundation of the structure in brickwork with lime mortar and random rubble masonry with lime mortar was in excellent condition even after the structural failure.

Compression tests on brickwork in lime mortar extracted from the collapsed structure, carried out at the Structural Engineering Laboratory of IIT Madras, showed that the compressive strength of the masonry was of the order of 2.0 N/mm2 (20 kg/cm2), which is a lower bound value for solid clay brickwork with lime mortar. The dry compressive strength of the brickwork with mud mortar would have been less than 1.0 N/mm2 (10 kg/cm2); however, this was not tested (NCSHS, 2015).

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Figure 6:(a) Load bearing walls with partially removed plaster; (b) Delamination and bulging of plaster due to crushing failure. (Image Credits – INTACH Pondicherry)

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Figure 7:(a) Distressed beam in upper floor of Pensionnat de Jeunes Filles; (b) View of Courtyard of Pensionnat de Jeunes Filles (Image Credits – NCSHS, IIT Madras)

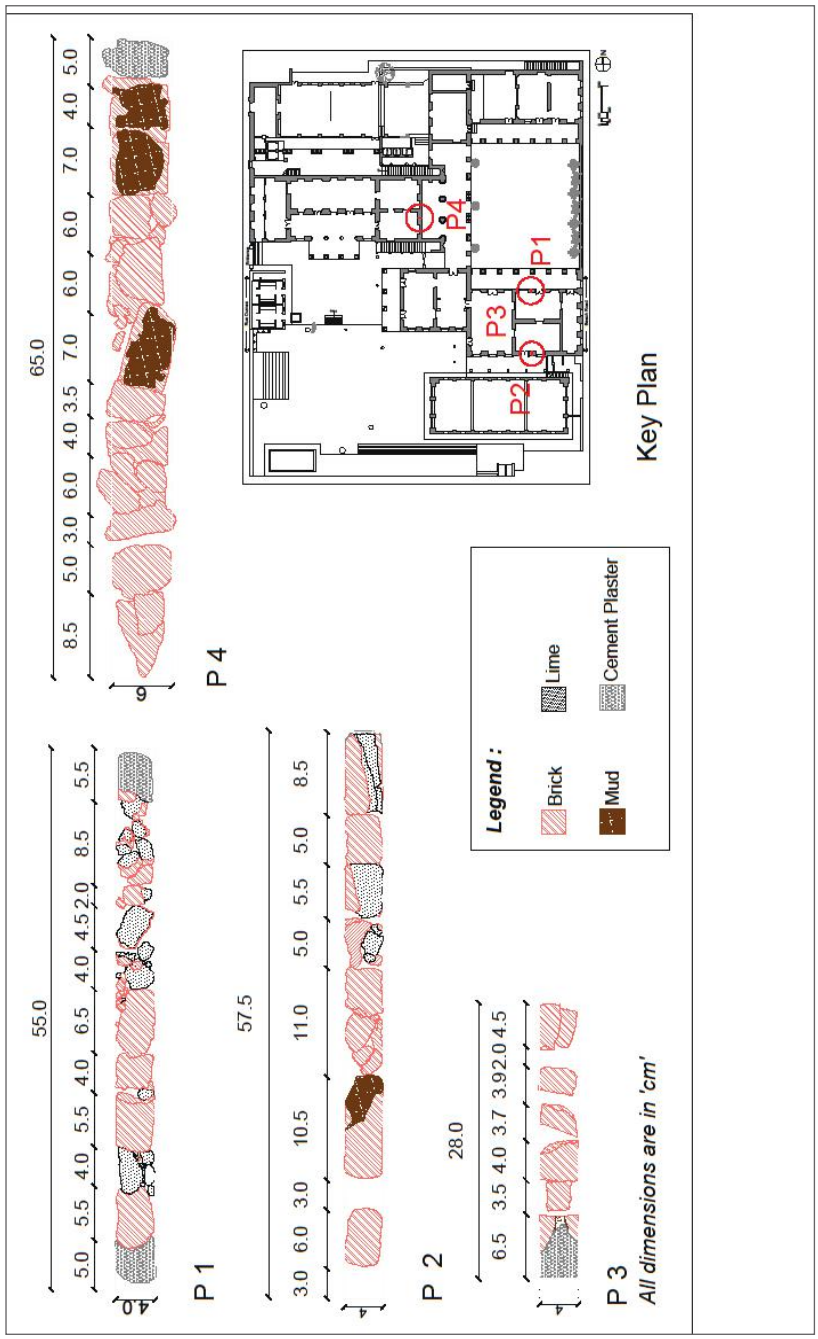

Figure 8:Masonry Core section from the school Pensionnat de Jeunes Filles.

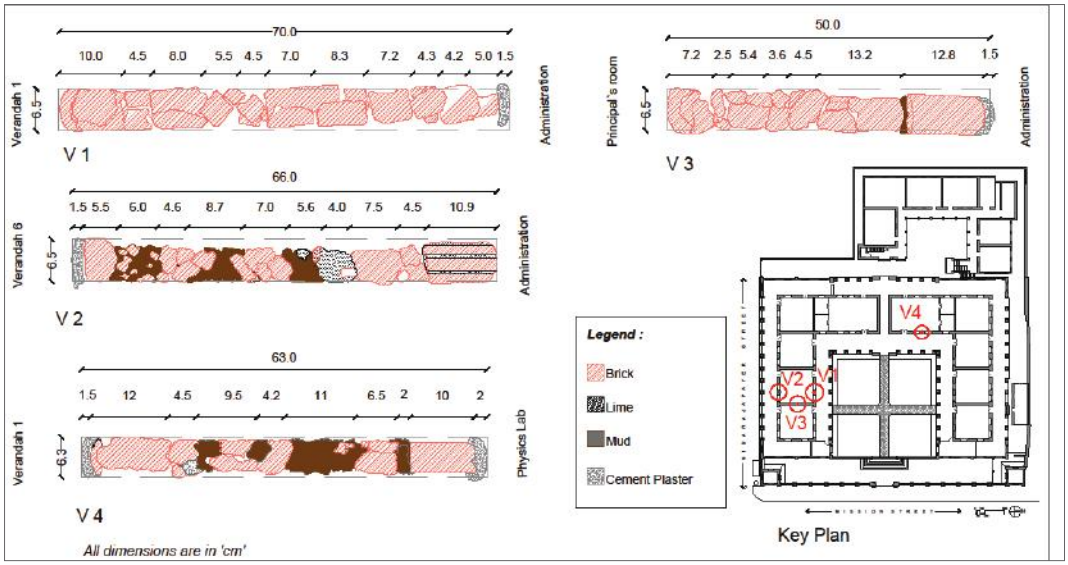

Figure 9:Masonry Core section from the VOC Government High School.

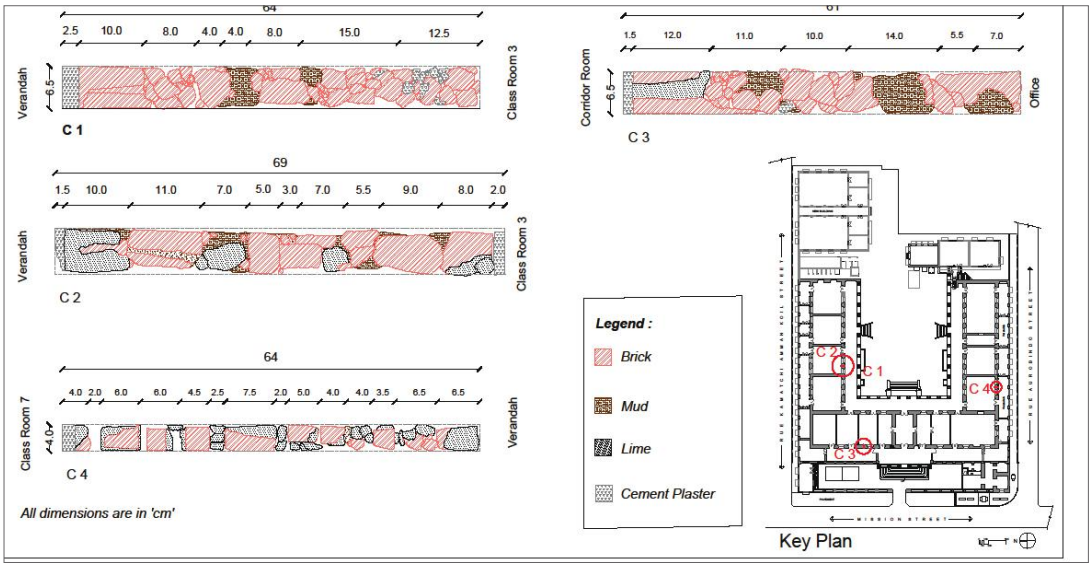

Figure 10: Masonry core section of Calve College

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Figure 11:(a) Deterioration due to water seepage; (b) Verandah with later addition of Calve College (Image Credits – NCSHS, IIT Madras)

2. Condition Assessment in Similar Historic Buildings

The collapse of Le Mairie resulted in a need for condition assessment of structures with similar characters (**Figure 7**), namely the Pensionnat-De Jeunes Filles Government High School, V.O. Chidambaranar Government Higher Secondary School, Calve College Government Higher Secondary School, Ecole Francaise d`Extreme- Orient (EFEO – Pondicherry Centre) and Old Lighthouse on Goubert Avenue. These structures were in use and categorized under institutional as well as utility typology. These structures were undergoing the process of decay and thus investigation was initiated by custodians of these properties namely Directorate of School Education, Government of Puducherry for school buildings, EFEO – Pondicherry Centre for and Central Excise and Service Tax, Pondicherry Commissionerate for Old Lighthouse respectively.

Core Extraction to Study Morphology of Walls

As part of initial investigation, core samples were extracted from all these buildings under the supervision of experts from National Centre for Safety of Heritage Strucutres (NCSHS) at IIT Madras. The core size and location were selected with focus on for understanding the wall morphology rather than determining strength of masonry. The locations were chosen to verify if the masonry were of similar pattern as Le Mairie. Surfaces with varying plaster finish (cement as well as lime) were selected. The purpose of extraction was to study the morphology of the walls. Two methods namely wet and dry core extraction was deployed. The core samples were extracted using HILTI Power Core drilling machines and samples varied from 4 cm to 7.5 cm in diameter. The core samples thus extracted were thoroughly documented.

Wet Core Extraction from School Buildings

The chosen schools – Pensionnat de Jeunes Filles Government High school, V.O.C School and Calve College are listed as Grade II-A heritage structure (INTACH, Pondicherry, 2012). These structures share similar architectural and structural systems as Le

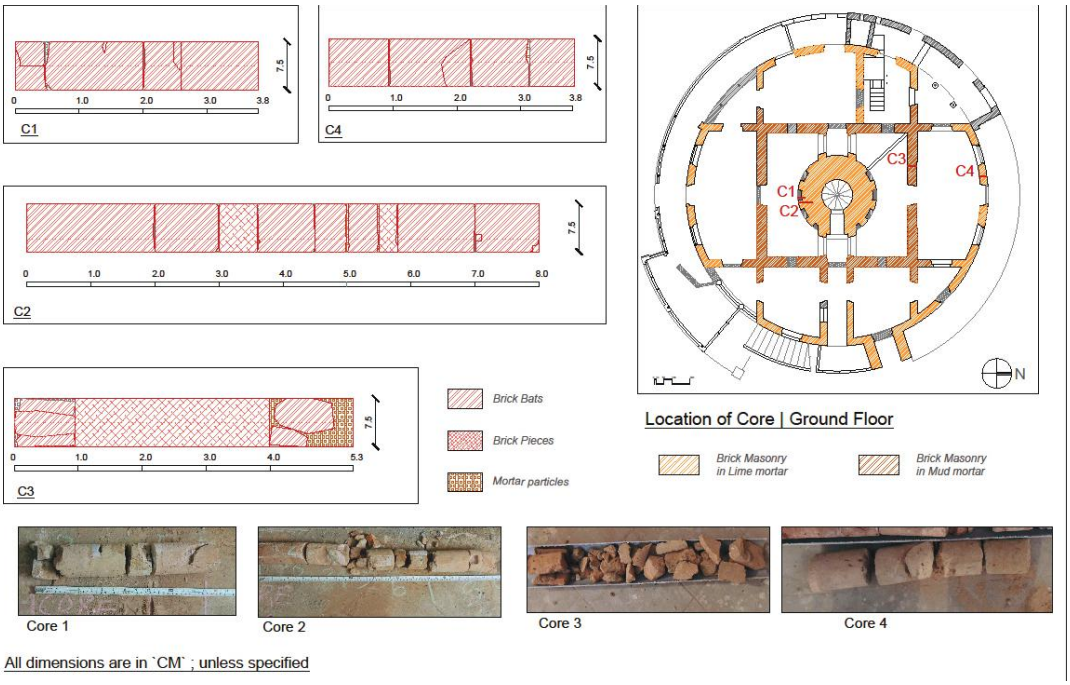

Figure 12: Masonry core section of Old Lighthouse Building.

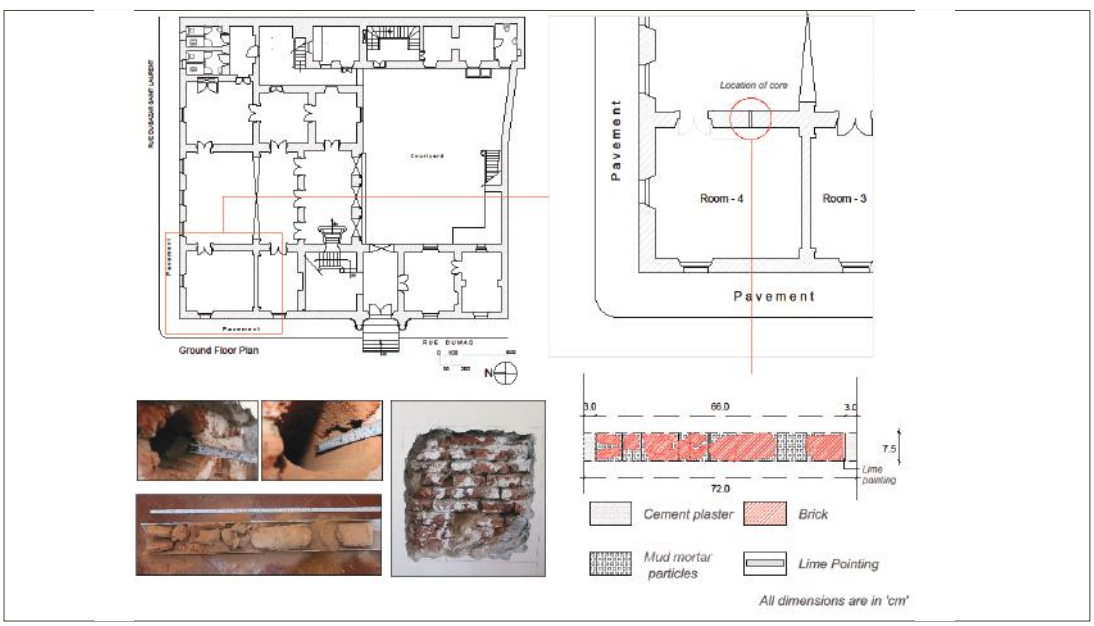

Figure 13: Masonry core section of EFEO Building.[7]

Mairie. Wet coring process was followed for these structures (**Figures 8, 9 10**). The core samples extracted were of 4 cm and 6.5 cm. Core extraction is a powered process in which heat is generated. Wet coring is preferred in order to keep the machine cooled and the blades clean when it is in use. However, the water jet is sufficient to wash out the mud mortar and could lead to moisture ingress in masonry. This issue of binding mortar washing out is not noticed in cement or lime mortar.

Dry Core Extraction from Other Buildings

Apart from these school buildings, Ecole Francaise d`Extreme- Orient (EFEO – Pondicherry Centre) on Dumas Street and Old Lighthouse on Goubert Avenue were two other buildings whose condition was assessed subsequently. Wet-core technique was employed in the three school buildings as well as in the Mairie Building. A conscious approach in examining the wall section of EFEO and Old Lighthouse structures was adopted. A dry core technique was adopted in this case to avoid washout of mortar (**Figure 12, 13**). Dry core technique is a time consuming exercise and it could result in quicker wear and tear of machine. A core of diameter 7 cm was extracted from the masonry. The quality of masonry bed joints was assessed thoroughly through this exercise. It was observed that here too similar intervention strategies as seen in other buildings were adopted i.e use of cement plaster as render.

Inference

1. Wet coring process resulted in washout of all loose materials and lead to moisture ingress in the masonry. Dry coring process is an appropriate method except being time consuming and causing faster wear and tear of drill bit. The biggest advantage is that it preserves the core section. The information of wall morphology helped in analyzing the condition of masonry.

2. The purpose of extracting core section was to identify wall morphology and not for estimating strength of masonry. It may be noted that for determining compressive strength of masonry wallettes are typically extracted and not cores as in case of concrete structures. The extracted core is used to identify the masonry typology, its constituents and condition of unit and binder. Based on this information on the masonry morphology, correlation with existing databases of masonry is made to determine possible residual strengths of the masonry for carrying out a quantitative assessment of safety.

3. The information derived from core extraction was helpful in decision making process for conservation of these buildings. As far as the three school buildings were concerned, condition assessment along with information of wall morphology helped in deciding whether the schools were in a serviceable condition or not. As regards to the EFEO building, based on the identified typology (similar to Mairie building) decision was taken not to load the structure further with new additions. While in case of the Old Lighthouse this investigation helped us in understanding different layers which existed in that building. It helped in clearly identifying the historic layer and later additions.

Relevance of Knowledge on Wall Morphology

1. The collapse of La Mairie de Pondicherry put forth questions regarding the structural conservation practices adopted by stakeholders and professionals in conservation projects of this magnitude. The assessment of the structural typology of La Mairie asserts that an inherent weakness existed in the massive masonry walls due to improper care. Such structural typology if it were to be kept in good health, regular repointing and plastering/ rendering with compatible materials is essential, particularly not creating impervious layers. The introduction of cement plaster on the brick masonry walls had severe impacts leading to decay and penultimate collapse. The removal of cement plaster triggered the entire collapse as it was performing the structural role in the load bearing capacity of the masonry walls. These walls did not show any external signs of distress during inspections prior to collapse. Only distress that was visible was issue of rising dampness. This entire exercise has many important lessons for professionals involved in built heritage preservation.

2. The health of such structures should be monitored periodically. A thorough condition assessment and documentation of material extant should lead to the choice of intervention strategy. The level of decay should be thoroughly analyzed and documented. The architectural documentation should have clarity in understanding of layers. This clarity should reflect in the architectural drawings with clear distinction between extant of materials being documented along with importance of cross sections.

3. A cautious approach must be adopted while intervening on historic masonry structures. Intervention on plaster surfaces should be with extreme care and after thorough examination.

> **The collapse of La Mairie de Pondicherry and Devaraja Market in Mysuru during conservation work are a case in point demonstrating the need for more rigorous investigation protocols prior to commencement of a conservation project.**

Before preparing the Detailed Project Report (DPR), there is need for an investigative phase with adequate scientific collection of data. This phase has to be formalized prior to commencement of work.

4. Removing plaster without assessment must be avoided. Removal if needed should be undertaken with proper guidance and executed only in segments. Actions due to water ingress in masonry walls have been a serious concern. It has been the cause of maximum decay in majority of historic masonry structures. However, it should be emphasized that the structural health of such typologies can be assured with regular maintenance and refurbishment of bed-joint mortars by repointing, and plaster.

5. A plaster detail for effective escape of trapped moisture content in masonry should be incorporated in the intervention. In public buildings in India, a practice is adopted wherein a 10-15 mm patch of plaster is removed and exposed. This uniform patch above skirting would serve as an outlet for moisture to evaporate.

6. Developing a maintenance protocol, periodic structural health monitoring of distressed zone, documenting the distress zone, developing sensitive intervention details should be form a part of the intervention strategy incorporated by the stakeholders.

Conclusion

A cultural heritage preservation project should encompass a detailed investigative phase for documenting geometry, structural typology and distresses. The collapse of La Mairie de Pondicherry and Devaraja Market in Mysuru during conservation work are a case in point demonstrating the need for more rigorous investigation protocols prior to commencement of a conservation project. The investigation should not be limited to visual observation only. It should encompass a complete understanding in typology along with morphological composition and it should adapt a quantitative approach to assessment of safety levels. Without a through diagnostic assessment, especially on masonry structures the conservation strategy developed could be piecemeal and can lead to accelerated decay or deterioration of cultural heritage properties. ■

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Notes:

[1] The official name of town and state is now Puduchery. In this paper the name Pondicherry refers to the Boulevard Town/ Municipality of Pondicherry (http://www.pdymun.in/puducherry-municipality-details.php)

[2] Bastide towns refer to the fortified medieval settlements in France.

[3] In India, built heritage is broadly categorized into Central protected, State protected and un-protected monuments. Protected monuments come under the purview of Ancient Monuments and Archaeological Sites and Remains Act -1958 or similar act by respective State governments. Unprotected monuments are the ones not coming under the Central or State government`s protection;

[4] Conservation initiative supported by European Commission, "Achieving Economic and Environmental goals through Heritage Preservation initiatives (2003).

[5] Data retrived from - http://www.unescobkk.org/culture/wh/asia-pacific-heritage-awards/previous-heritage-awards-2000-2013/2008/award-winners/2008mr2/2 and http://www.unescobkk.org/culture/wh/asia-pacific-heritage-awards/previous-heritage-awards-2000-2013/2000/award-winners/2000mr1/

[6] A similar collapse scenario was identified in adobe structures (mud constructions) in the New Mexico region of USA and traditional adobe constructions in Chile.

[7] Figure 8, 9,10,12,13 are based on documentation drawings prepared by INTACH, Pondicherry Chapter.

[8] Wallettes refer to small thin masonry wall which are used for

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